DOCUMENT RESUME

ED 466 582 IR 021 317

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TITLE	Constructivism in Web Based Learning Revisited: Explorers with a Machete in a Hypermedia Rain Forest.
PUB DATE	2001-00-00
NOTE	7p.; In WebNet 2001: World Conference on the WWW and Internet Proceedings (Orlando, FL, October 23-27, 2001); see IR 021 310.
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Computer Uses in Education; *Constructivism (Learning); Educational Technology; *Hypermedia; *Instructional Design; Models; *Multimedia Instruction; Multimedia Materials; Navigation (Information Systems); *Systems Development; *Web Based Instruction

ABSTRACT

This paper describes the Full-Hypermedia Educational Systems Development Model (FHESDM) for designing hypermedia systems that takes advantage (in terms of cognition and learning) of non-linear navigable structures and multimedia. The model is based on constructivist principles, including the subjectivity of the learning process, and assimilation and accommodation (i.e., blind exploration will involve a problematic situation for the student and solving it will advance the knowledge creating process), as well as some aspects of Ausubel's Significant Learning Theory. The model includes the contract concept that allows superimposing several navigation structures on an information structure to support a more customizable way of navigating through the system without taking the control from the student. (Contains 11 references.) (MES)

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Constructivism in Web Based Learning Revisited: Explorers with a Machete in a Hypermedia Rain Forest

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Abstract: Nowadays, e-learning is booming: thousands of online courses and dozens of universities online. However... Quantity has little to do with "real innovation". In very rare occasions, online courses and teaching institutions are breaking with the rules of the Gutenberg Galaxy. They are designed on a linear basis, and based on conventional text. What if we try to put state-of-the-art technology aside for a while? What if we try to think exclusively in terms of cognitive efficacy? Then we will be able to create non-dependent on technology models for teaching online. We've done so, and developed our *"Full-Hypermedia Educational Systems Development Model"*, which intends to take full advantage (in terms of cognition and learning) of non-linear navigable structures and multimedia. We want to have our students exploring a rich, hypermedia environment. We want them to face the problem of finding their own way in the middle of (only apparent) chaos.

Introduction: Fun Fairs and Real Rain Forests

Nowadays, Internet is packed with good online courses. Thousands of them. Some include additional navigational aids, interactive exercises, simulations and links to other websites of interest; the best even add tests and a virtual notepad and student tracking facilities. Probably they will do wide use of e-mail and discussion forums. But in the end the structure is always the same: linear. There are plenty of examples of very good courses that lack one only thing: breaking with the traditions of Gutenberg Galaxy.

Most of the courses one comes across in the Web are, in some way, like fun fair's stalls: a very restricted and controlled environment where the student has no option but clicking now and then the "next page button". They are just a "safe" imitation of "real" hypermedia. All in all, perhaps it's about time to take advantage of the cognitive potentials of exploratory navigation in hypermedia networks. In practice, we mean, not only in theory. That was our aim when we begun to develop our *"Full-Hypermedia Educational Systems Development Model"* (FHESDM).

We situate the learner in a real rain forest (not a jungle: it makes no sense to build completely chaotic systems), instead of a fake. We want him to struggle in order to find a way. His way. We want to transform navigation (though it may sound bizarre) into a problematic situation. One the kind Jean Piaget proposes as generators of new cognitive structures development. Our aim? To make students construct their own knowledge. But not from social interaction and collaborative learning, the nowadays most common implementation of constructivist principles in Internet. That's undoubtedly a very good philosophy but... we felt like trying another approach. We wanted to focus in cognitive constructivism, based on the "blind" exploration of a rich hypermedia domain.

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Imagine an explorer that, with a machete in his hand, wanders around an unknown for him rain forest. No map. Just never-ending vegetation. Obviously, while he walks he'll begin to build a mental map (a deformed one, for sure) of the place: rivers, openings, trees types, animals,... will allow the explorer to imagine a structure of the place, based on his own and personal way of moving and on the "designed in advance" structure of the rain forest (remember: our course won't be chaotic, being its structure very carefully thought). When eventually he gets a high enough hill, he'll be able to watch the whole rain forest, and realize the mistakes in his mental map. He'll locate the places he knows yet, and then will locate new ones. But above all he will have the chance to discover the real relationships between the locations. After all this "correcting work", he'll go down again, and have the chance to pay more attention to specific details, his knowledge of the information space completed now.

After the whole process, something is for sure: our explorer has got to know the rain forest very well.

Making Your Way in the Middle of the Woods

As we've mentioned previously, our model is based on constructivist principles (see Larios 98). Specifically:

- Subjectivity of the learning process: The student must explore the system according to his own interests. That way he will construct his own mental schema. The differential feature in our model (right the opposite to other approaches, like that of Ausubel and Novak's (Novak 01)) is that we'll provide no map to the brave explorer: he must recreate the structure from scratch. He must navigate the structure "from inside" before contemplating the whole view.
- This "blind exploration" will involve a problematic situation for the student, who, by solving it, will advance his "knowledge creating process" (assimilation and accommodation).

But constructivism isn't the only milestone of our model. We've adopted (and adapted) some aspects of Ausubel's Significant Learning Theory (Ausubel 68) too. For instance, the information structure of the courses will present first the most general ideas, providing more details as the learner moves on to deeper levels in the structure. We'll also use the idea that any new knowledge to be learnt must be attached to previous known concepts, already in the student's cognitive structures.

Some way, we want to offer the user a rich context where to play his own and personalized role (see Ascott 99), developing his own cognitive structures and augmenting, at the same time, the "incidental knowledge" (Lee 99). Our aim is to get it without eliminating narrative (Laurillard 98) and without making "cognitive overload" explode (see Plowman 99 and Lee 99). In this section we'll refer to the "Structural Dimension of Hypermedia", specifically: those aspects related to the information structure and the navigation structure. In a sense, we'll be trying to convey Structural Knowledge to the learner.

Thus, the structure of the system must be designed with an only purpose in mind: conveying a structure of knowledge. Certainly, our approach inherits the philosophy of Novak's Concept Maps (Novak 01), differing from them in two basic aspects: we propose a more methodical (and somewhat rigid) design of the network (in order to minimize the problems described in the previous paragraph), and we avoid showing an "aerial view" of the system to the student. If learning by discovery and exploration is a milestone in our model, the aid of a map from the very beginning may encourage an exploration of the woods as a whole, not of every tree and its relationship with the rest. We want an inmersive course, no a landscape to explore.

We begin the design by creating a hierarchy of layers, in which any node is a summary of all the nodes that "hang" on it. That way, penetrating into the lower layers in the hierarchy means to obtain more details of previously revised concepts (remember Ausubel's proposals). On the other hand, going back towards the root of the hierarchy allows the student to see the knowledge space from a more holistic point of view.

Once we have developed a hierarchical space of contents, it's about time to establish the necessary relationships between pairs or pages (or, more generally, nodes). In an effort to keep a sense of modularity in the course, during these first steps in the design process we'll limit to set links between nodes situated in the

same sublayer, i.e., nodes sharing the same father. That way we'll be creating small navigational subspaces, whose "gate" will be the father node.

Up to now, the proposed model looks fine, but there is little special, little different on it. This is a most suitable time to introduce a new element in our model: the "contract" concept. Thanks to it, we'll be able to superimpose several navigation structures upon an only information structure, allowing for a more customizable way of navigating through the system without using Intelligent Tutoring Systems (i.e., without taking the control out from the hands of the student, a fundamental constructivist idea).

Actually, contracts are a concept inherited from the Object Oriented Design and Programming world. For us, contracts will be the different sets of links a node can show to the student, depending on the path followed to get there. That way, an only node of contents can be inserted into several navigation structures, that's to say, into several ways of conceiving the knowledge space, all in the same hypermedia system (Fig. 1).

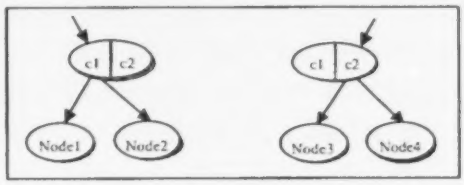

Figure 1: Node with two contracts.

So Blue the Rivers, so Green the Trees

Other important kind of knowledge a course has to convey is Declarative Knowledge. The nowadays way of doing so online, most of the times, is by means of text and graphics. We intend to situate our learner in the middle of a colorful rain forest. We'll try to take full advantage of multimedia, in order to complement exploratory learning. It's what we call the "Exposition Dimension" of hypermedia.

We like to consider multimedia as the third dimension of hypermedia: a set of vectors, each associated to a node in the two-dimensional network.

A vector represents the amount of multimedia information displayed by a node, and, of course, the way in which that information is displayed. We'll dedicate the rest of this section to justify and describe the way in which our FHESDM copes with this vectors, intending always to keep on the track of constructivism and cognitive efficacy: what we have so called the "docuscheme", a cognitively sound model to present education oriented multimedia information.

Reading on a screen is annoying and frustrating. People read on books and magazines, but nobody would be willing to read on a TV set, for instance. Screens are the land of pictures and animations, not of written words.

Let's use pictures then but... what kind of pictures? Well, static ones, preferably (animated pictures are too "volatile"), and shocking to the perceptive system of the student (this will encourage attention and retention, as mentioned by (Trumbo 98)). Any other feature? Yes, indeed. It seems interesting to provide a summary of the node's contents: let's employ an only picture then, captivating and eye-catching to the student, but at the same time behaving as a big and high level scheme of the node's contents. An "advance organizer", in Ausubel's terminology.

And then... What else? We want to convey contents, not just a scheme of the contents. We need a way to put a large amount of information inside our fashionable node. One interesting possibility is audio. Audio is always a powerful communication resource (see McKillop 98). What's more: by introducing oral narration in

our system, we are combining static picture with documentaries' principles. We are getting closer to the concept of "Docuscheme", now.

In order to get even closer, and to increase in an ultimate way the "information capacity" of our node, we could think of explaining every concept in the scheme by means of some kind of video, animation or whatever multimedia element the designer considers appropriate.

So now we have a big, colorful graphical scheme, explained by means of audio and acting as an umbrella that covers an enormous amount of multimedia information. It sounds fine: a node as catching as a documentary and as accurate as a textbook. It only lacks a few complementary elements more.

First, accessing the information in a node in a film-like way (not in vain we are trying to imitate television documentaries in some way), i.e., from the beginning to the end without interruptions, may be fine for the first viewing, but not for the next visits to the node. Consequently, each part or the scheme must be accessible separately, once the student is inside the node.

Second, perhaps we mustn't eliminate completely the text. Perhaps reading a textual version of the contents after viewing the full multimedia presentation may be a great opportunity for the student to analyze in full detail the information, to impose the student's information acquisition pace on the prefixed pace of video and audio. We must admit the text back in our system then, but only as a secondary element, a post-viewing resource.

Making the Most of Your Machete

Daily life in the rain forest is no at all contemplative. On the contrary, you must be continuously moving, and doing and achieving in order to survive. Well, our situation is somewhat better but... we shouldn't forget "surviving by doing", anyway. In this case, learning by doing. ¡We need to include opportunities for strong interaction in our web courses! Our model still lacks the third kind of knowledge: Procedural Knowledge.

"Le. .ing by doing" complements the "learning by exploring" and the "learning by watching" approaches used up to now (see Scott 00). And the most common way to implement learning by doing in an online system is interactivity. But we mean real, full interactivity, not just navigating. What's more, we propose to separate very clearly interactive activities from the rest, more passive ones. That way, we reduce fragmentation, as we are not interrupting expositions of declarative knowledge.

In order to satisfy the interactivity (more precisely, the "separated interactivity") requirements of the course, we have created the concept of "satellite". Satellites are complementary nodes that "orbit around" a declarative node (see the reason for their name?). Every satellite contains an interactive activity of any kind (exercises, tests, simulations, real examples, study cases...) (Fig.2).

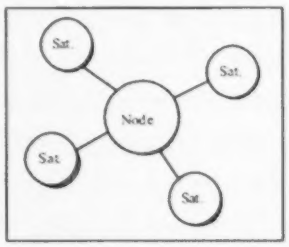

Figure 2: A node and its satellites.

Any question about the design of satellites? Oh, fine. Unfortunately, we don't have any answer. Each satellite depends strongly on the declarative contents it intends to complement, the available resources, the designer's objectives, etc. Anyway, if you want a hint, we recommend not to display the satellite in the same

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window you are displaying the declarative node, but in a smaller, detached one: that way the context in which the activity is being realized will be before the eyes of the student constantly.

Welcome to Our Virtual Rain Forest

Though our intention was to develop a model beyond temporary technology restrictions, it seems somewhat important to introduce a real implementation of the model, in order to show that we are describing a feasible way of creating online courses, that creating that sort of rain forest is not a dream. We'll explain the technological items we are using for the time being, but keeping always in mind that, in all probability, they'll change very often in the future.

The aim of our implementation is to develop a core of navigational aids easily adaptable to any set of HTML documents. That way, once you have the contents of the course (a set of multimedia web pages), you just need to superimpose on them the core of tools previously developed to have the system running.

These tools have been built using typical Internet programming resources: DHTML for the user interface, Java Servlets for navigation control and user tracking, and XML for data representation (Fig. 3).

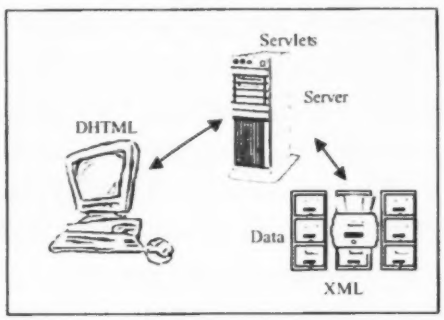

Figure 3: Nowadays implementation of the model.

This is a graceful way to implement the Structural Dimension. What about the Exposition Dimension? We are currently evaluating some options. Specifically, we are considering Java Applets, XML (SMIL, more specifically) with DHTML, and Macromedia Director or Flash. Though there is no definitive conclusion yet, for the time being we are using Macromedia software. The reason for this can be summed up with an only word: simplicity. The design process our model involves is rather complex, and it doesn't seem a good idea to increase the complexity even more.

There is also the problem of bandwidth. Although it's increasing very quickly, this remains the main obstacle to take full advantage of docuscheme principles over Internet. In the meanwhile, vector's graphics and streaming techniques are a good option.

Anyway, we are looking for a personalized solution, as we don't think appropriate to depend on proprietary applications. Specifically, we are trying to combine Java applets with SMIL data representation, in order to create our perfectly customized "docuscheme's viewer".

Conclusions and Future Work

When we begun our research a few years ago, we undertook two premises: first, we intended to obtain something not depending on temporary technology; second, we wished to "make the difference significant", paraphrasing the famous "The Non-Significant Difference Phenomenon" website.

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We accomplished the first by developing an abstract model. In our opinion, that's the only way to walk ahead technology, and not always behind. If we concentrate exclusively on applying the state-of-the-art technology, we'll never be able to move fast enough: technology will always be faster, and bringing some kind of stability to online learning will always be a dream impossible to get into practice. Abstract models, based on pedagogical and cognitive principles, give us the chance to "take over control" of the situation. We'll ask technology for what we need, not the opposite.

The second premise is reflected in the kind of model we have created. If we put real technology aside, at least for a while, we can think in a "riskier" way. We can think of instructional systems' features different from the habitual. In a word, we can work with features that help us to transform the use of online learning into a really significant difference. We've tried to reach that point breaking with linearity and text, and making extensive use of exploration and multimedia. In a word: developing our own way of applying constructivist principles to Web Based Learning.

And next? A mountain of research and development is still to be done. The path is long, and we've just begun to walk. From an abstract point of view, we are eager to keep on improving our model, realizing new experiments, and making up new ways to obtain full advantage of the Web. And what about a more technological point of view? Well, the design process in our model, as it has been described here, involves a very complicated sequence of stages, and requires an immense amount of work. So we are planning the development of a software tool specially thought to make design work far easier and convenient, eliminating routine tasks and facilitating collaborative design.

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